Pedobiologia **32,** 1–5 (1988)
VEB Gustav Fischer Verlag Jena

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A method to manipulate population densities of arthropods in woodland litter layers

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With 2 figures

(Accepted: 86-12-15)

1. Introduction

One of the main difficulties in field experiments on predation or competition is the manipulation of population densities. The impact of predation on a prey population can be assessed for example by reducing the number of predators and competition is best studied by manipulating the density of the population(s) concerned (COLWELL & FUENTES, 1975). Recently the need for such studies in order to gain a better insight in the role of competition and predation in structuring communities has been stressed (SCHOENER, 1983).

The litter layer of woodlands is a habitat which is inhabited by animal species of all trophic levels represented by numerous individuals on a relatively small area. Therefore, these woodlands are suitable and interesting for the above mentioned experiments. However, the complex structure of the litter layer seems to prevent the removal of large numbers of animals without extensive disturbances. For example, the simple method of removing animals from the litter by sieving (VERHOEF & DE GOEDE, 1986) undoubtedly changes the structure of the litter layer. The use of insecticides (EDWARDS *et al.,* 1969) seems unsuitable for this purpose because it lacks the specificity needed.

In the present method the animals' natural behaviour to move upwards under certain circumstances (BOWDEN *et al.,* 1976; BAUER, 1979) is used. By (partly) removing these animals population densities can be reduced without disturbing the structure of the litter layer.

2. Method

Upward movement of the animals is both induced and enabled by applying a layer of defaunated litter on top of the litter that has to be treated. After a certain period the introduced layer is removed together with its immigrants. The method was tested in pine plantations in enclosures which were made with stainless steel plates. The litter layer in the enclosures was covered with a coarse mesh (1 cm) on top of which a layer of defaunated litter was spread. This introduced layer was ca. 5 cm thick and consisted of litter the A_{00} and A_0-F horizon (*sensu* WALLWORK, 1970), i.e. freshly fallen and partly decomposed pine needles. The litter from was defaunated by drying it in the air for a few days; absence of animals was checked by sieving and handsorting. The surface of each enclosed plot and of the mesh was 1 m^2 in all three experiments. The mesh (iron) had a vertical edge (5 cm) around which allows one to lift the introduced layer from the litter layer. Except in experiment 1 strips with glue were placed on the inside and outside of the fence to prevent migration; a gauze net was spread over a plastic tube frame to prevent animals out of the trees falling into the plots (Fig. 1). At the end of a treatment the animals from the introduced layer (i) and from the litter layer (l) were collected by sieving and handsorting in experiment 1 and 2 and by extracting in Tullgren funnels in experiment 3. The data concern total counts, except for experiment 1 in which the total number of Collembola and mites collected were estimated by taking a sample. The efficiency of the method is expressed as the percentage of individuals in a group which migrated into the introduced layer, i.e. 100 i/(i + l).

The three experiments were conducted in *Pinus nigra* stands; experiment 1 and 2 on the Wadden island Schiermonnikoog and experiment 3 in one of the Ijsselmeer polders. Experiment 1 was carried out in summer during a rainy period; it was planned to see if treatment for 5 days (2 replicates) made the animals migrate upwards into the introduced layer. Experiment 2 was carried out in the second half of September during a dry period. It was planned to

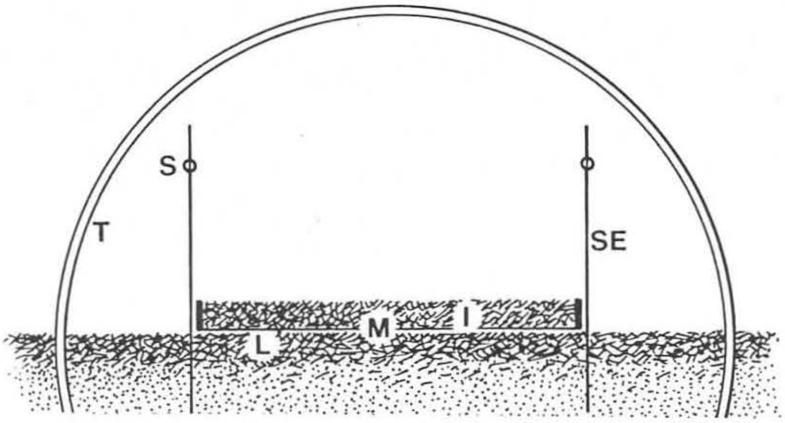

Fig. 1. Cross-section through an enclosure; S = strips with glue; SE = stainless steel plates; T = tube frame; L = litter layer; I = introduced layer; M = mesh.

establish how the efficiency of the method depends on the duration of the treatment (1,2 or 3 days, one replicate each) and whether the method is selective. Only the number of surface dwelling springtails in the two layers was counted.

Experiment 3 was carried out in the second half of October during a dry and relatively cold period. Two enclosures were constructed; in one of the plots, a rain shower (8 mm) was simulated after the introduction of the defaunated litter in order to establish a possible effect of moisture on the efficiency of the method. The treatment lasted one day.

3. Results

In experiment 1 the efficiency of the method was very high (Table 1), especially for springtails and mites. The replicated efficiencies in these groups suggest that the method is reliable given equal conditions. The litter layer, being covered for 5 days by the introduced layer, appeared to be quite moist and an increase in fungi mycelium growth was noticeable. Since the objective in applying this method is a change in animal numbers and changes in habitat conditions have to be avoided, treatment of shorter duration is desirable.

Table 1. Total number of animals in introduced layer (i) and litterlayer (l) in two plots (A; B) of one m^2 each; duration of the treatment was 5 days

		A	%	B	%
Collembola	i	2800-3470	93	959-1937	95
	l	165- 301		24- 120	
mites	i	3678-4422	96	1556-1995	94
	l	72- 239		60- 168	
carabid beetles	i	13	72	12	100
	l	5		0	
spiders	i	183	68	179	79
	l	85		47	

Note: The numbers given for Collembola and mites are 95 % confidence limits of total number per m^2. The percentages show the efficiency of the treatment, 100 i/(l + l).

Table 2 shows that the efficiency concerning the three springtail species (in experiment 2) hardly increases after a treatment of 1–2 days. The method appears to be selective depending on the transpiration rate of the species (Fig. 2). It has been shown that the transpiration rate is indicative for the moisture dependence and micro-habitat selection of a species (VERHOEF & WITTEVEEN, 1980; VEGTER, 1983). Drought tolerant springtail species (with a relatively low transpiration rate) live closer to the surface of the litter layer than drought sensitive species. Therefore the conclusion is justified that in this group the efficiency increases as the drought tolerance of the collembolan species is higher and as the species lives closer to the surface in the litter layer.

Table 2. Efficiency of the method, 100 i/(i + l), concerning the springtail species *Orchesella cincta* (Linné), *Lepidocyrtus cyaneus* TULLBERG and *Tomocerus minor* (LUBBOCK)

	O. cincta	*L. cyaneus*	*T. minor*
1 day	81 (208)	69 (242)	45 (3473)
2 days	94 (225)	79 (335)	46 (3477)
3 days	94 (209)	84 (272)	54 (3487)

Note: The treatment lasted one, two or three days. In parentheses the total number (i + l) of individuals is given.

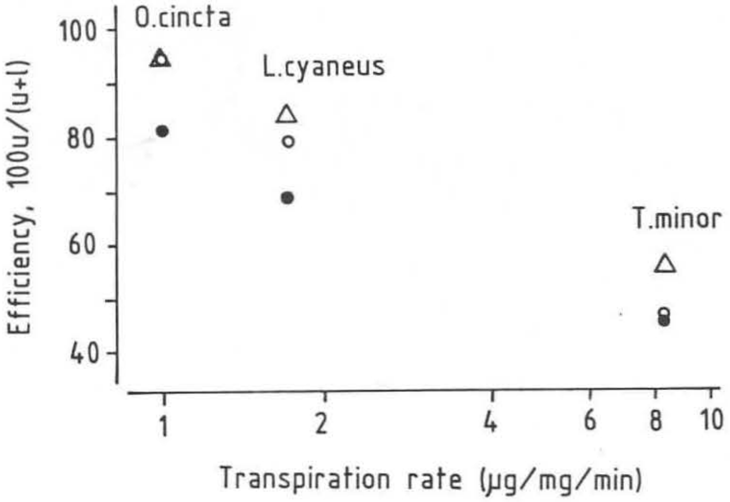

Fig. 2. Efficiency of the method in relation to the transpiration rate of the species and the duration of the treatment: one day (●), two days (○) and three days (△); transpiration rate data derived from VEGTER, 1983.

The relation between efficiency of the method and drought tolerance of the animals suggests that the moisture condition of introduced layer and litter layer is important for the efficiency of the method. This assumption was confirmed in experiment 3 (Table 3). The efficiency, which was relatively low overall, is raised substantially in all groups, except for the spiders, by wetting the litter. Again the selectivity of the method is evident: the efficiency concerning *Orchesella villosa* (GEOFFROY) lies between those for *Orchesella cincta* (L.) and *Tomocerus minor* (LUBBOCK) which is in agreement with the transpiration rate of the three species (Vegter 1983). Also in the carabids the efficiency of the method seems to depend on the moisture/microhabitat preference of the species. The majority of individuals of *Notiophilus biguttatus* F. (10 out of 16) occurred in the introduced layer. This species showed a marked response to "wetting". In contrast all individuals of *Loricera pilicornis* F. (8) remained in the litter layer. The former species has been described as euryhygric (BAUER, 1975) and as occurring in dry sites (LINDROTH, 1945), whereas the latter prefers moist to wet sites (DEN BOER, 1976).

Table 3. Efficiency of the method, 100 i/(i + l), when applied for one day in a dry and in a wet plot

	Collembola			Carabidae		Staphylinidae	Araneida
	T. minor	*O. villosa*	*O. cincta*	*N. biguttatus*	*L. pilicornis*	*Philonthus* spec.	
dry	3 (2177)	36 (181)	55 (690)	25 (4)	0 (5)	16 (38)	19 (227)
wet	18 (1373)	48 (235)	68 (657)	75 (12)	0 (3)	28 (35)	19 (202)

Note: In parentheses the total number of individuals (i + l) is given.

4. Discussion

In developing the method it was assumed that after the introduction of a defaunated litter layer colonization occurs from the litter layer below. This process will have an undirected component and a directed component. The undirected component is a consequence of the trivial movements of the animals (comparable with diffusion). Because locomotory activity differs between species and fluctuates with temperature this component of colonization will vary accordingly. For example, low temperature may have caused the overall efficiency in experiment 3 to be relatively low.

The directed component arises from effects of the introduced layer on conditions in the litter layer, e.g. moisture- and light conditions. The litter layer covered with the introduced layer shows an increase of the moisture/humidity level. The arthropods respond to this increase by moving upwards. The response is stronger as moisture conditions in the litter layer are higher. This mechanism of directed movements appears from experiment 1 in which the litter layer after a treatment of 5 days during a rainy period was nearly defaunated and from the effect of "wetting" in experiment 3. Drought tolerant species are extracted from the litter layer far more efficiently than drought sensitive species. This difference stands to reason since the former species are more surface dwelling than the latter. Moreover, in these species the directed component might be relatively strong. For example, during rainy periods many springtails take refuge on tree trunks (Browden *et al.*, 1976). Bauer (1979) showed that the propensity of a springtail species to climb trees depends on its drought tolerance. Avoidance of excessive moisure has been put forward as an explanation for these vertical migrations (Vegter, 1983). The selectivity of the method in extracting animals from the litter layer suggests that the method is most useful for animals living near to the surface. For deeper living animals the method has to be applied for a longer period. However, the duration of the treatment is restricted since micro organism activity in the litter layer is affected. Therefore it is better to apply the method for 1 or 2 days and to repeat the treatment when necessary. The thickness of the upper layer (ca. 5 cm) was chosen arbitrarily; the relation between efficiency and thickness of the introduced layer remains to be investigated.

5. Acknowledgements

I am indebted to Professors Els N. G. Joosse and John A. Wallwork and to Drs Ab Kessler and André van Loon for comments on an earlier draft of the manuscript. I thank Jacob Asjes, Sigrid Bestebroer, Dirk-Jan Leek and Jos van der Linden for assistence in field work, Désirée Hoonhout for typing the manuscript and Luigi Sanna for drawing the figures.

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Synopsis: *Original scientific paper*

Ernsting, G., 1988 A method to manipulate population densities of arthropods in woodland litter layers. Pedobiologia **32**, 1–5.

An *in situ* method to reduce population densities of arthropods in woodland litter is proposed. The method can be used in field studies on competition, predation or decomposition. In enclosed plots a layer of defaunated litter is introduced on top of the litter layer. A coarse mesh between these two layers allows for removing the introduced layer with its immigrants at the end of the treatment. As a result of this treatment population densities in the litter layer are reduced without disturbing the structure of the litter layer. The method has been tested in pine stands. Its efficiency to extract animals from the litter layer varies between species and depends on duration of the treatment and on temperature/humidity conditions.

Key words: Arthropoda, Collembola, Acari, Carabidae, Staphylinidae, Araneida, population density, woodland litter, manipulation.